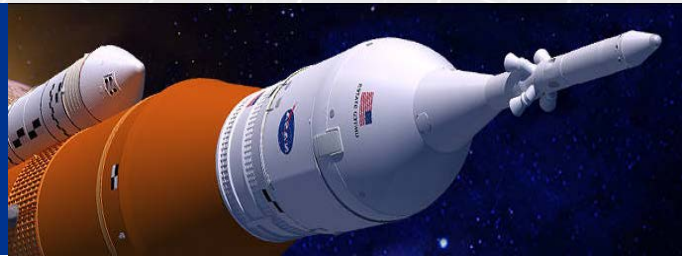
The Weather Analysis Display (WAND) Tool: Developing a Meteorological Data Display Tool for Situational Awareness during Day of Launch of Space Launch Vehicles Using Python



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Background

- Atmospheric environments are an important element in day-of-launch (DOL) operations of space launch vehicles.
- NASA Marshall Space Flight Center Natural Environments Branch provides multiple functions supporting DOL operations.
  - Generates a vertically complete profiles for trajectory and load calculations using the Profile Envision and Splicing Tool (Orcutt et al.; 2017)
  - Monitors atmospheric conditions for situational awareness

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Weather Analysis Display (WAND) Introduction

- The USAF's Eastern Range contains of a highly dense network of weather instrumentation.
  - A network of weather towers
  - Weather balloons
  - A network of Doppler Radar Wind Profiling (DRWP) systems
    - Tropospheric DRWP at ~48-MHz
    - Boundary Layer Profilers at 915-MHz
- WAND was developed by MSFC NE to provide MSFC NE DOL operators situational awareness capability by presenting data in a multitude of ways.
  - Observations
  - Climatology
- Designed to operate within the "highly secured" environment at the Huntsville Operations Support Center.
  - WAND was coded using Python 3
  - Has few dependencies
    - Numpy – array handling
    - Scipy – mathematical functions
    - Matplotlib – data visualization
    - Tkinter – create and execute the Graphical User Interface (GUI)

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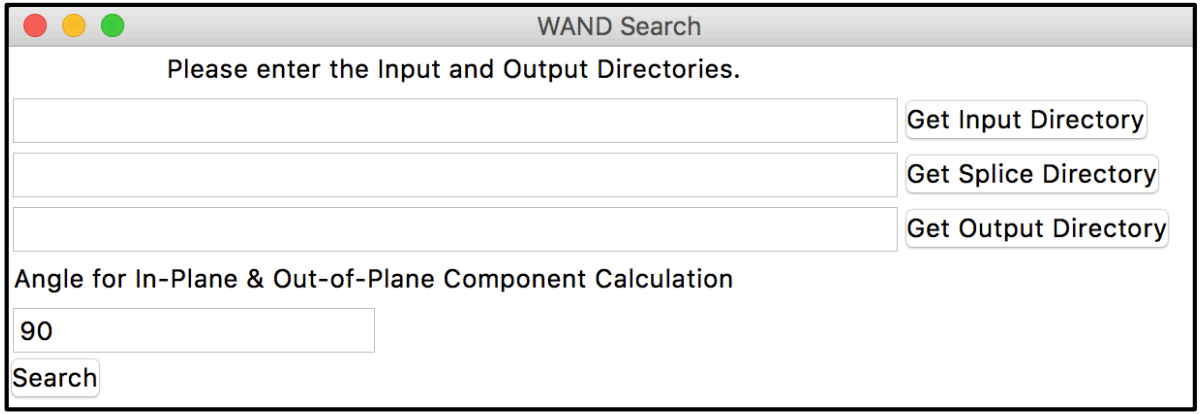
WAND Design



- This window is the initial window that appears when WAND is started.
- Allows the operator to select the desired input and output directories as well as set the desired angle for in-plane and out-of-plane wind component calculations.
- Clicking the “Search” button once all directories are supplied will get WAND to search for any data from the past 24 hours.

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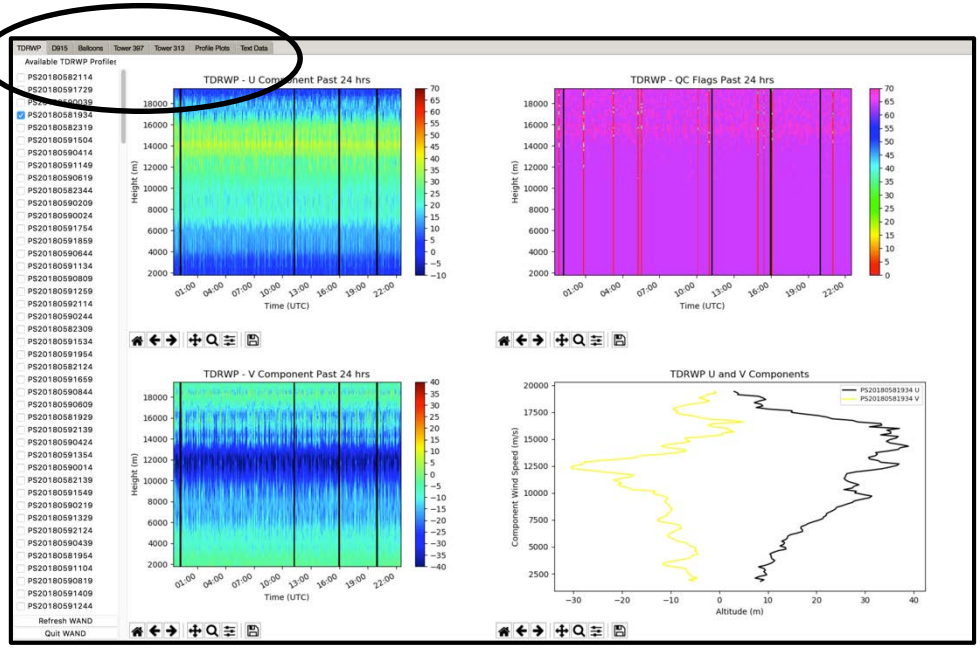
WAND Design

- WAND uses tabs to control which system is being displayed.
  - Tropospheric DRWP (TDRWP)
  - 915-MHz DRWP (D915)
  - Balloons
  - Tower 397 (located at the launch pad)
  - Tower 313 (located approximately 5 km from the launch pad)
  - Profile Plots
  - Text Data



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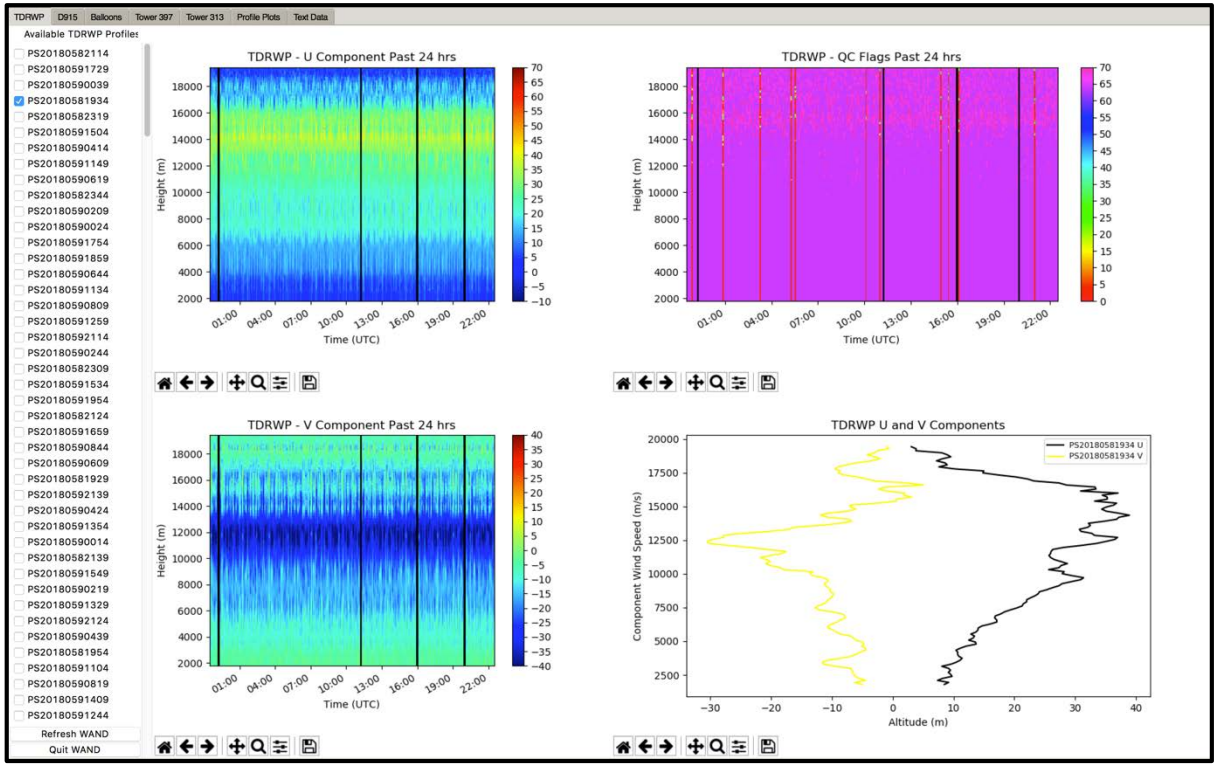
WAND Design

- WAND opens to the TDRWP tab.
- The TDRWP tab contains time-height cross-sections of the U and V wind components, the TDRWP's QC flags, and profile plots of U and V.



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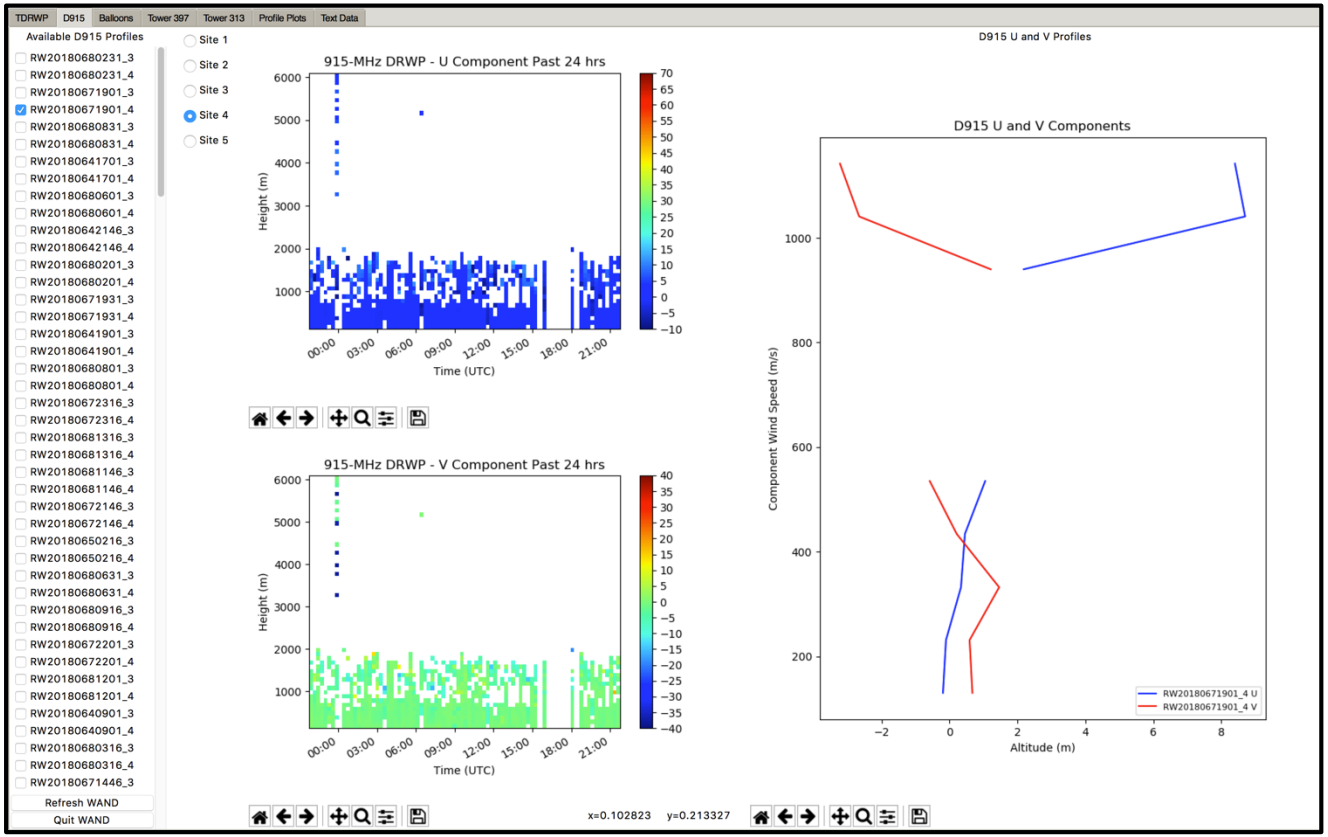
WAND Design

- The D915 tab is nearly identical to the TDRWP tab, but does not have a QC flag time-height cross-section plot.



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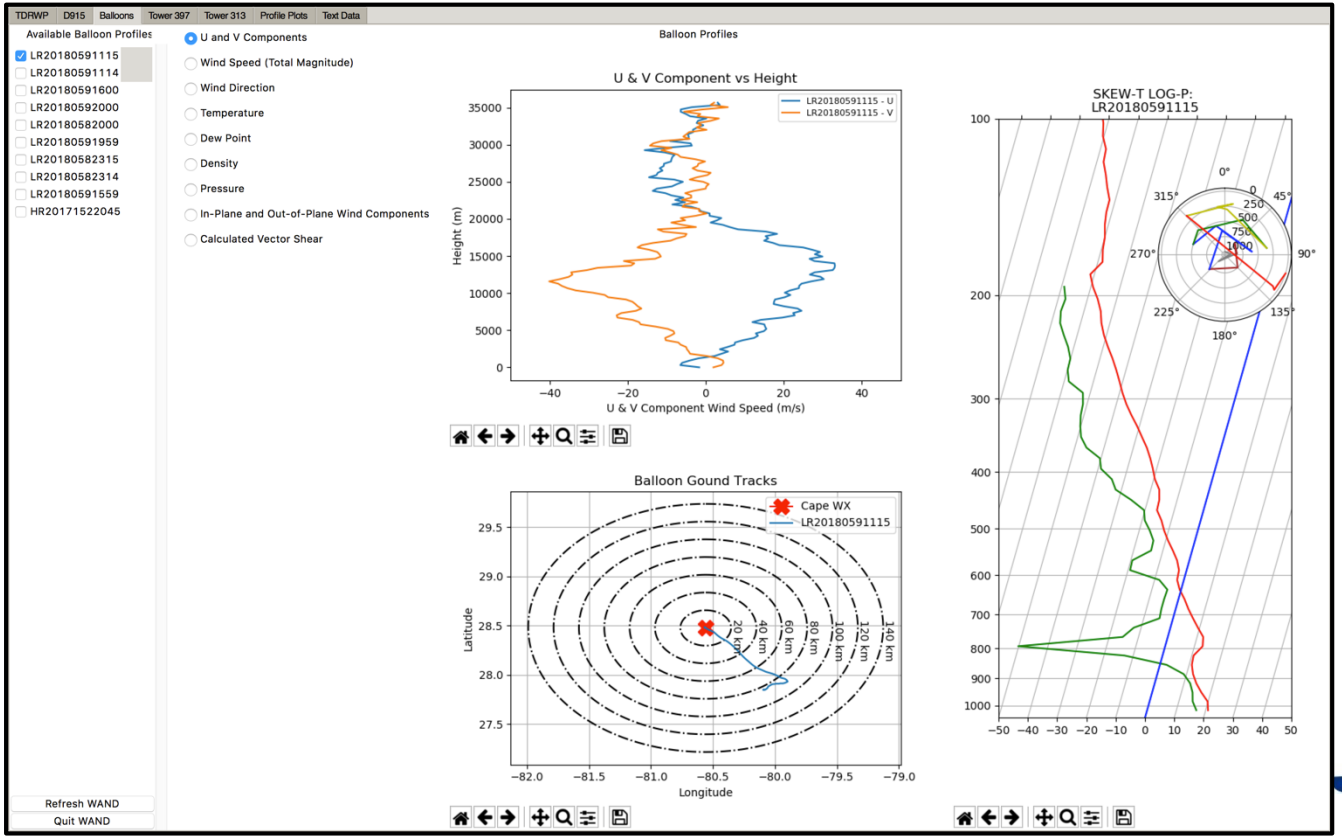
- The Balloons tab displays the vertical profile of all variables reported by the balloon systems, ground tracks of the balloons, and Skew-T Log-P.



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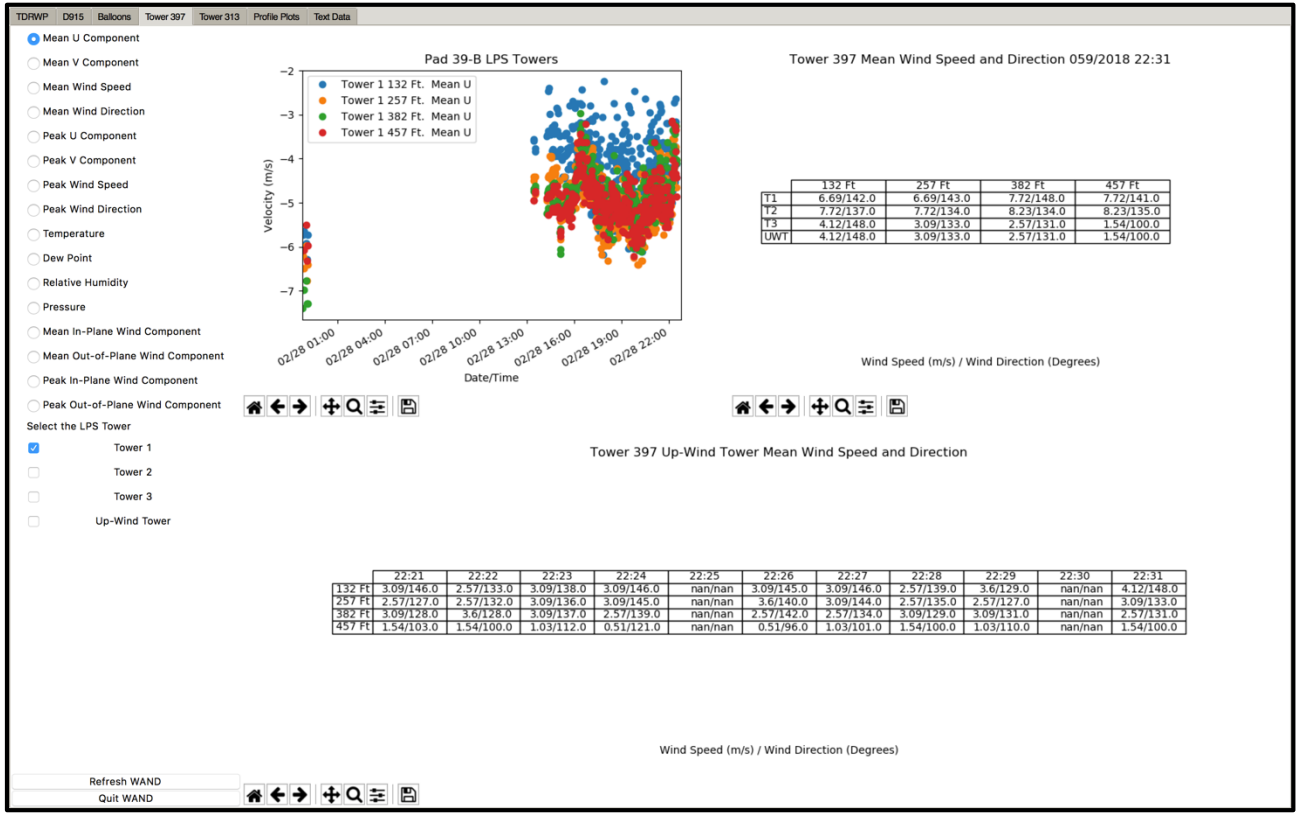
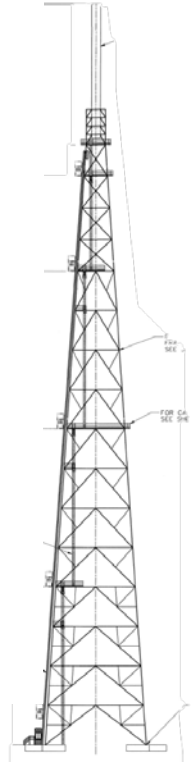
- The Tower 397 tab displays a time series of any variable that is measured by the towers, a table of the current conditions from all sensors, and a table of time series of the past 10 minutes of data from the up-wind tower (Orcutt et al., 2016).



	132 Ft	257 Ft	382 Ft	457 Ft
T1	6.69/142.0	6.69/143.0	7.72/148.0	7.72/141.0
T2	7.72/137.0	7.72/134.0	8.23/134.0	8.23/135.0
T3	4.12/148.0	3.09/133.0	2.57/131.0	1.54/100.0
UWT	4.12/148.0	3.09/133.0	2.57/131.0	1.54/100.0

	22:21	22:22	22:23	22:24	22:25	22:26	22:27	22:28	22:29	22:30	22:31
132 Ft	3.09/146.0	2.57/133.0	3.09/138.0	3.09/146.0	nan/nan	3.09/145.0	3.09/146.0	2.57/139.0	3.6/129.0	nan/nan	4.12/148.0
257 Ft	2.57/127.0	2.57/132.0	3.09/136.0	3.09/145.0	nan/nan	3.6/140.0	3.09/144.0	2.57/135.0	2.57/127.0	nan/nan	3.09/133.0
382 Ft	3.09/128.0	3.6/128.0	3.09/137.0	2.57/139.0	nan/nan	2.57/142.0	2.57/134.0	3.09/129.0	3.09/131.0	nan/nan	2.57/131.0
457 Ft	1.54/103.0	1.54/100.0	1.03/112.0	0.51/121.0	nan/nan	0.51/96.0	1.03/101.0	1.54/100.0	1.03/110.0	nan/nan	1.54/100.0



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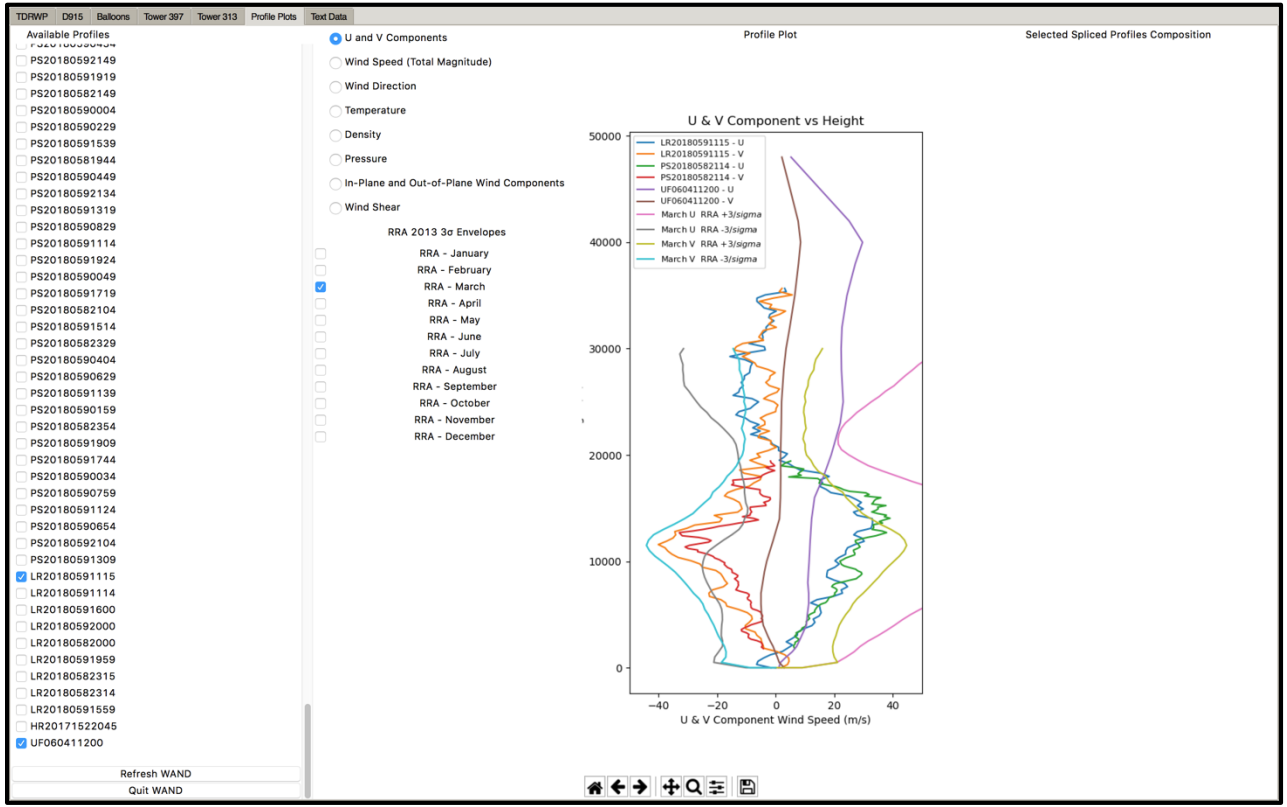
- The Tower 313 tab is identical in layout to the Tower 397 tab.

	6 Ft	12 Ft	54 Ft	162 Ft	204 Ft	295 Ft	394 Ft	492 Ft
NE	nan/nan	2.57/141.0	4.63/140.0	6.17/139.0	7.2/140.0	nan/nan	7.72/144.0	7.72/140.0
SW	nan/nan	2.57/184.0	4.63/127.0	6.69/134.0	7.2/130.0	7.2/137.0	nan/nan	7.72/129.0
UWS	nan/nan	nan/nan	nan/nan	7.2/137.0	nan/nan	nan/nan	nan/nan	nan/nan

	22:21	22:22	22:23	22:24	22:25	22:26	22:27	22:28	22:29	22:30	22:31
12 Ft	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan
54 Ft	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan
162 Ft	6.69/139.0	6.17/137.0	nan/nan	nan/nan	nan/nan	7.2/136.0	7.2/136.0	6.69/136.0	nan/nan	nan/nan	7.2/137.0
204 Ft	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan
295 Ft	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan
394 Ft	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan
492 Ft	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan	nan/nan

WAND Design

- The Profile Plots tab displays vertical profiles of any measurement from all of the DRWPs, balloons, Profile Envision and Splicing Tool (PRESTO) spliced profiles, upper level profiles, and statistical envelopes.



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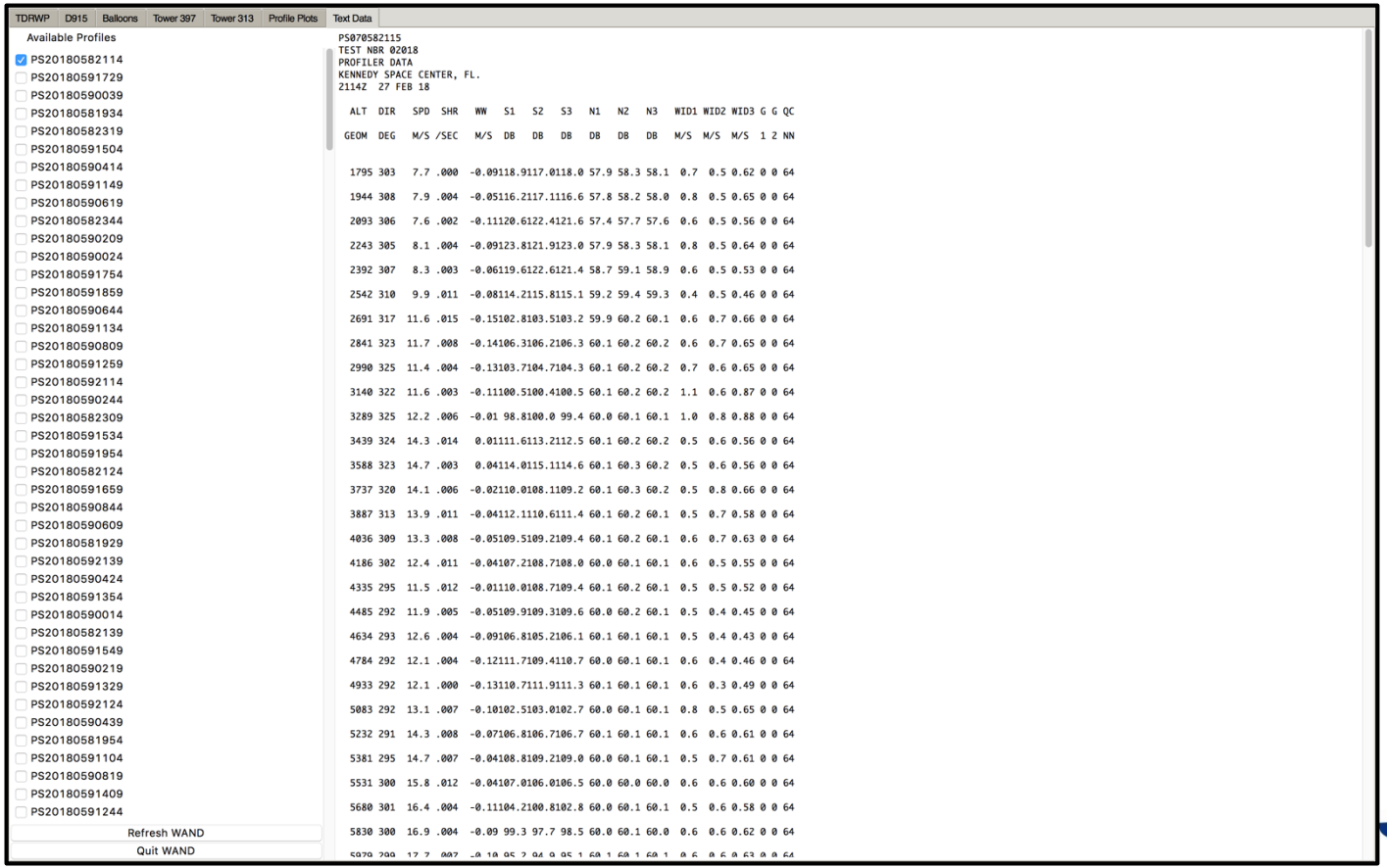
WAND Design

- The Text Data tab displays the selected data file as text.



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Summary

- MSFC NE developed a tool, WAND, using Python to provide DOL personnel with displays of the meteorological conditions at and around the launch site for situational awareness.
- WAND can display data from all systems at Kennedy Space Center and Cape Canaveral Air Force Station, as well as upper level wind forecasts and statistical envelopes.
- Forward work
  - Finish Formal Acceptance Testing

References

Orcutt, J. M., J.C. Brenton. (2016) The Quality Control Algorithms Used in the Process of Creating the NASA Kennedy Space Center Lightning Protection System Towers Meteorological Database. Fifth Aviation, Range, and Aerospace Meteorology Special Symposium. New Orleans, LA, Amer. Meteor. Soc. P828.

Orcutt, J. M., R.E. Barbré, J.C. Brenton, R.K. Decker. (2017) The Profile Envision and Splicing Tool (PRESTO): Developing an Atmospheric Wind Analysis Tool for Space Launch Vehicles Using Python. Seventh Symposium on Advances in Modeling and Analysis Using Python. Seattle, WA, Amer. Meteor. Soc.

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Questions?